Simulation of radiopulses from atmosphere-skimming extensive air showers with ZHAireS-RASPASS

I F L P
CONICET
U N L P

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Aires 19.04.08

aires.fisica.unlp.edu.ar (S. Sciutto)

- Solves bug in treatment of not-so-short lived hadrons in 19.04.00
- Support custom (i.e. GDAS and constant) atmospheres
- EPOS LHC, Sybill 2.3d, QGSJetII04 and older hadronic models
- Includes (since 1999) the possibility of handling special particles

  A special particle is a shower pre-processor (i.e. to handle exotic particles, gamma pre-shower, etc), that also also allows for custom geometries (i.e. up-going showers)

ZHAireS 1.0.30a for Aires 19.04.08

aires.fisica.unlp.edu.ar/zhaires

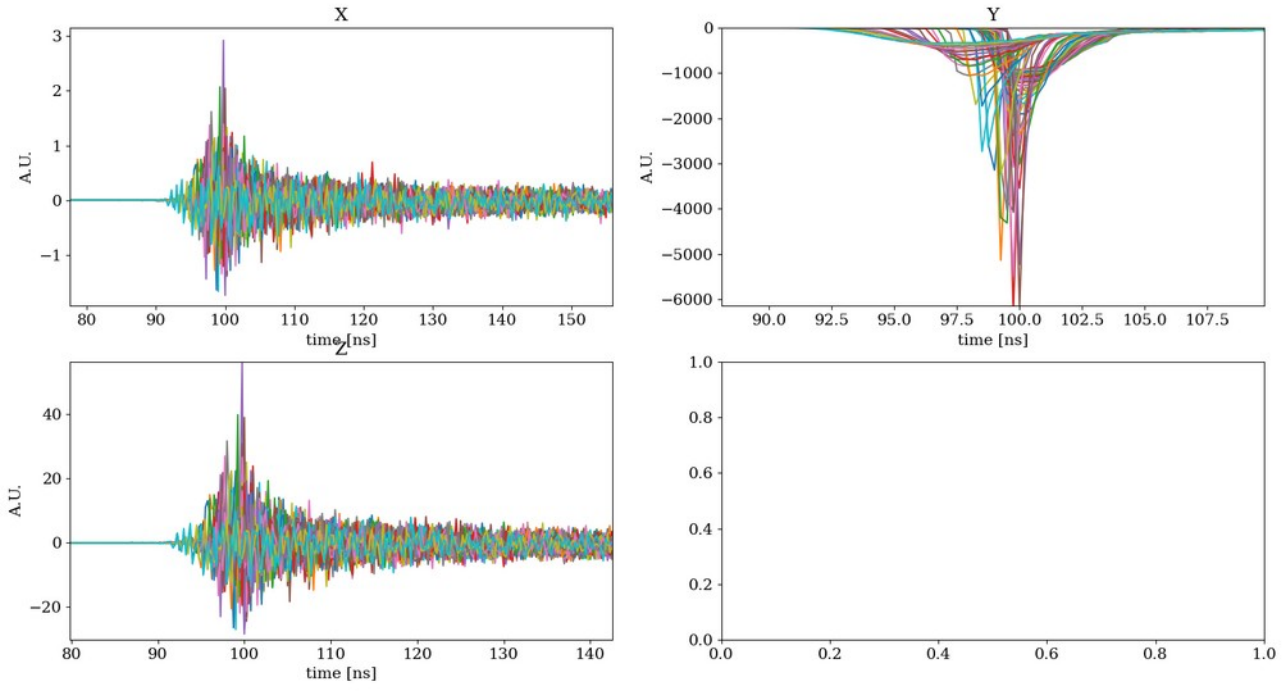
- Aires + ZHS algorithm (time and frequency domain)
- No longer a "custom version" of Aires –> Integrated installation
- Regular Aires Input commands (no external config file)
- CoREAS-like output (needs just a change of units)
- Support to resume sims → Run sims for as long as you want
- Exponential index of refraction only (but an alpha version with density-dependent index exists, ask me about it if interested)

Raspass is an Aires Special Primary for Atmospheric Skimming Showers

- Born in 2011 as a special primary to study ANITA direct events, it evolved into a stand-alone version of ZHAireS
- Includes numerous modifications to allow for up-going, down-going and atmosphere skimming showers (but no change in physics)
- Regular Aires/ZHAireS Input commands
- Multi-primary (i.e. use tau decay products to start)

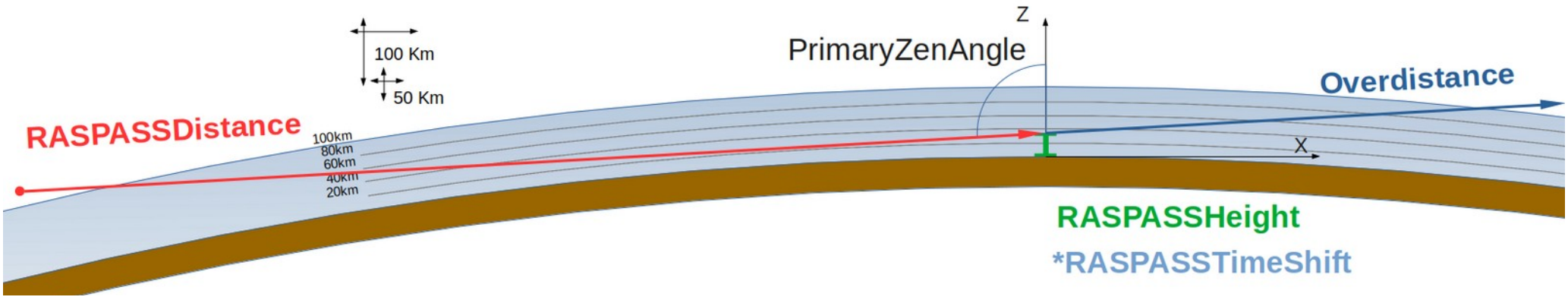
("Raspar" means "to graze or scrape" in spanish)

As promised on the title



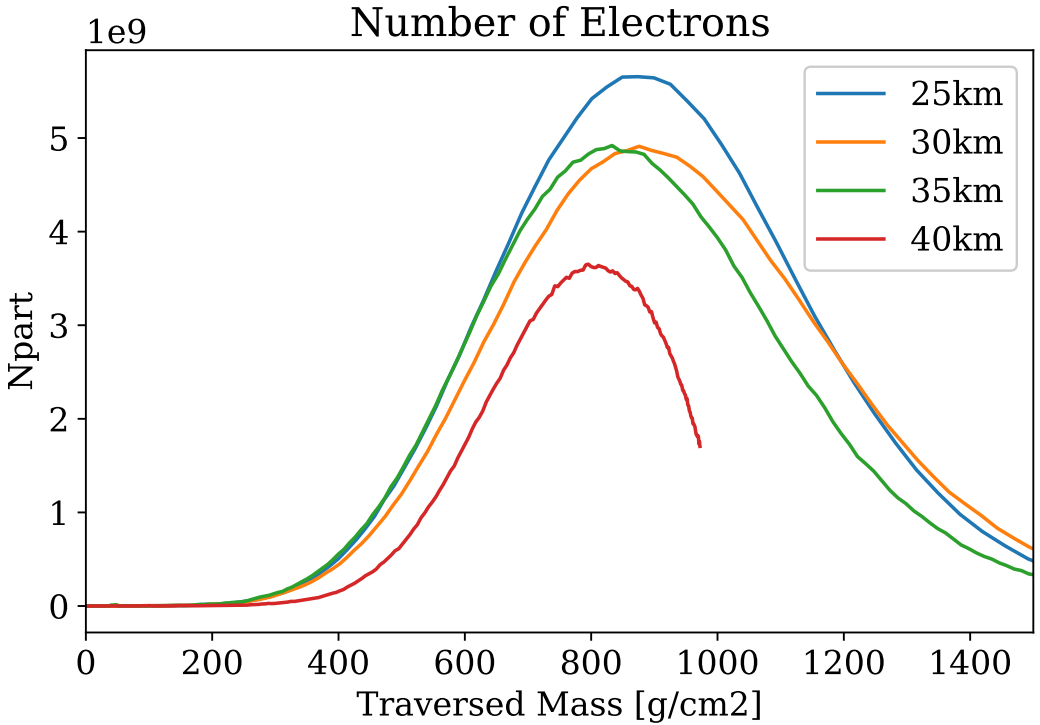
Example RASPSASS geometry

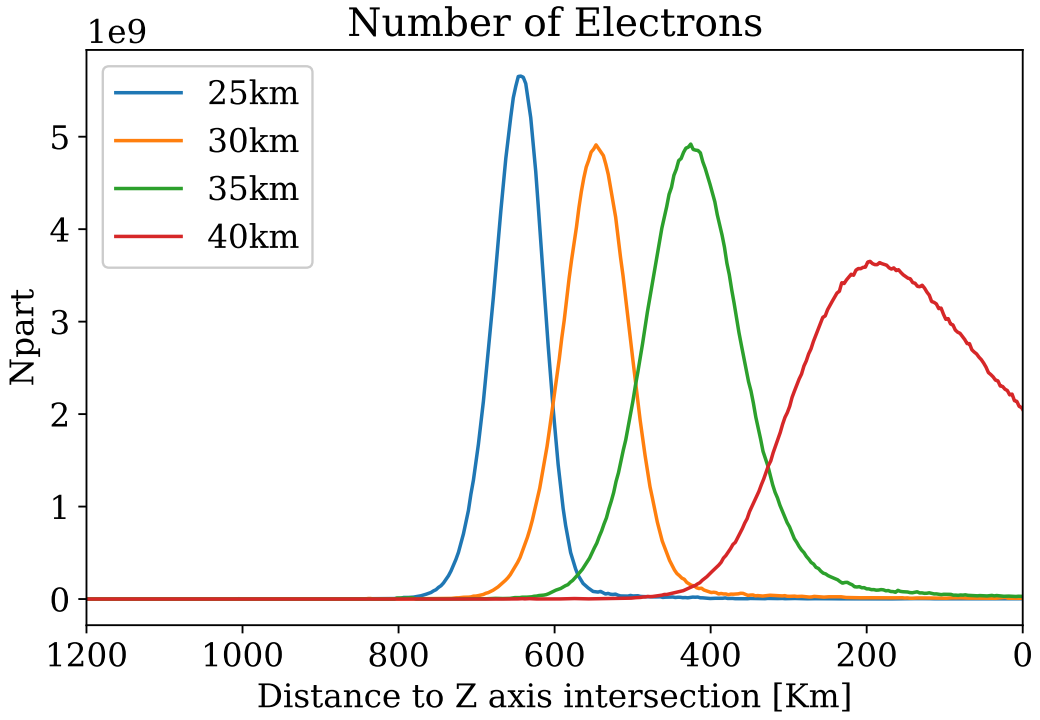
To scale!



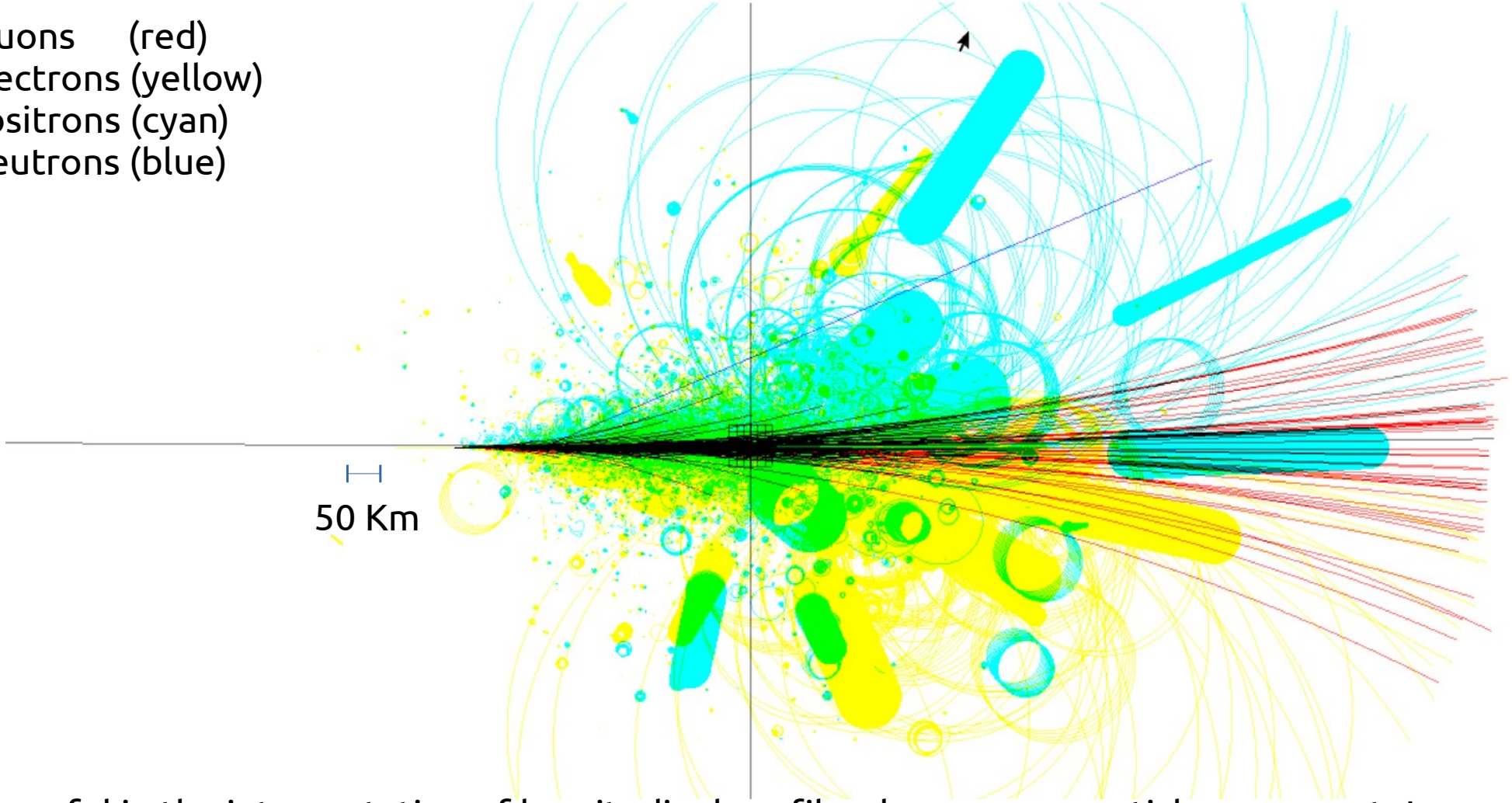
93.25 Zenith crossing the Z axis at 35 km altitude, Injected at 1500 Km from the crossing, Normaly t=0 at the crossing, but this is also configurable.

Aires longitudinal profiles



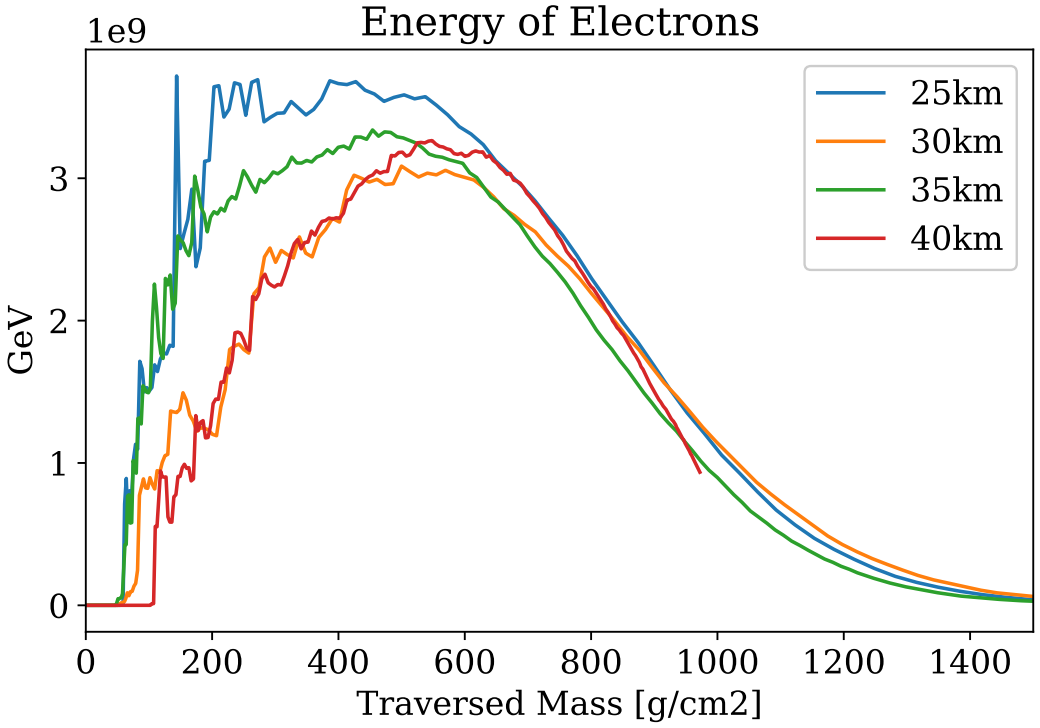


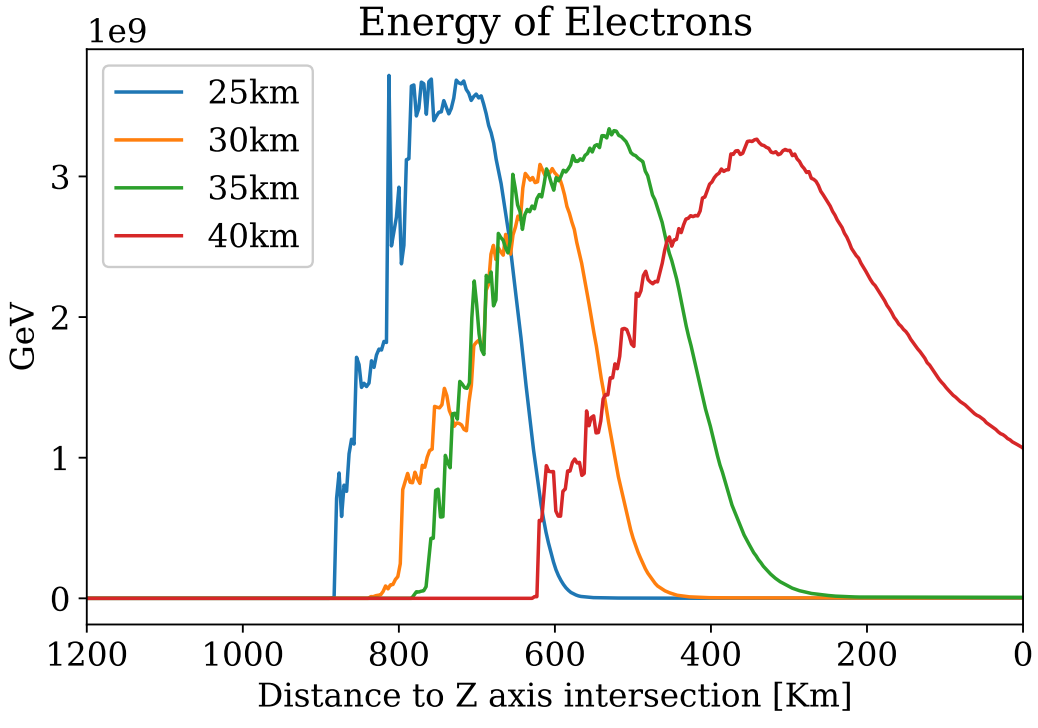
Muons (red)
Electrons (yellow)
Positrons (cyan)
Neutrons (blue)



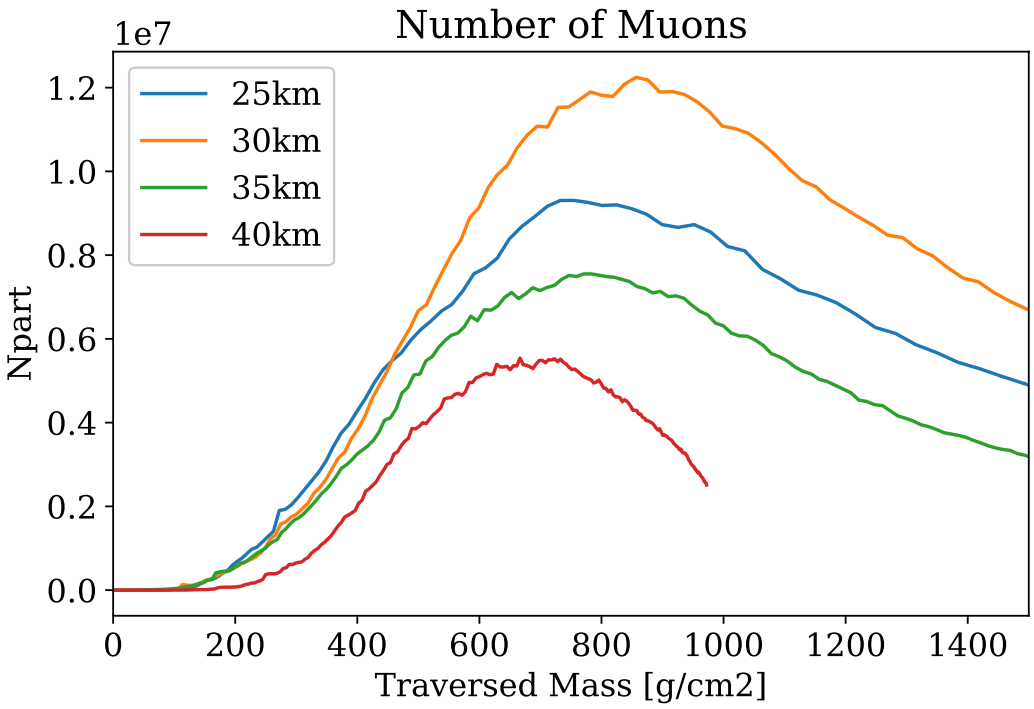
Be careful in the interpretation of longitudinal profiles, low energy particles can gyrate!
If they do so in the interface of an observing plane...they get counted multiple times!

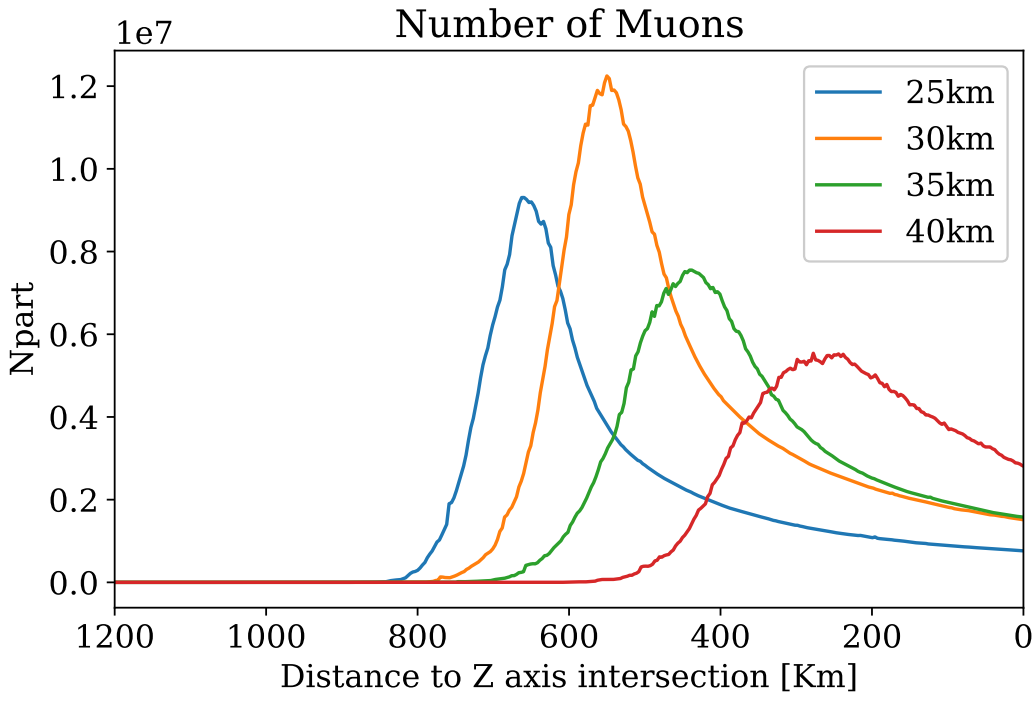
Aires longitudinal profiles





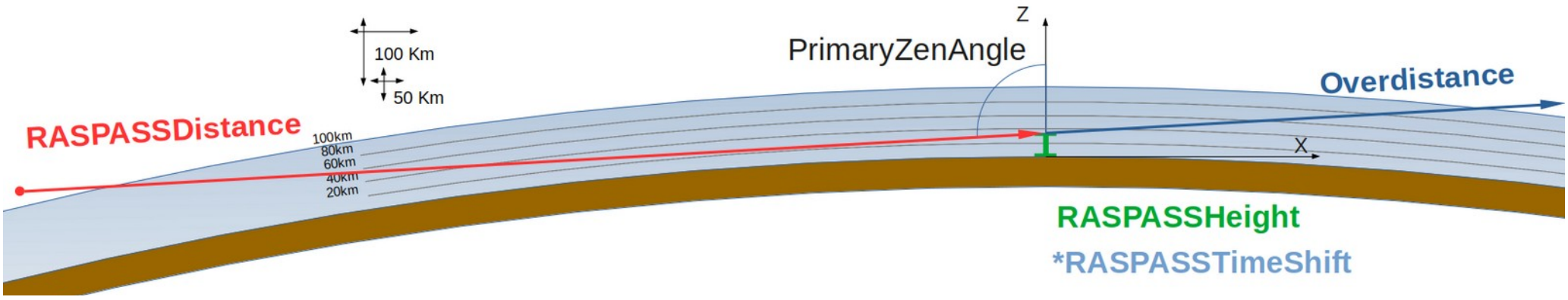
Aires longitudinal profiles





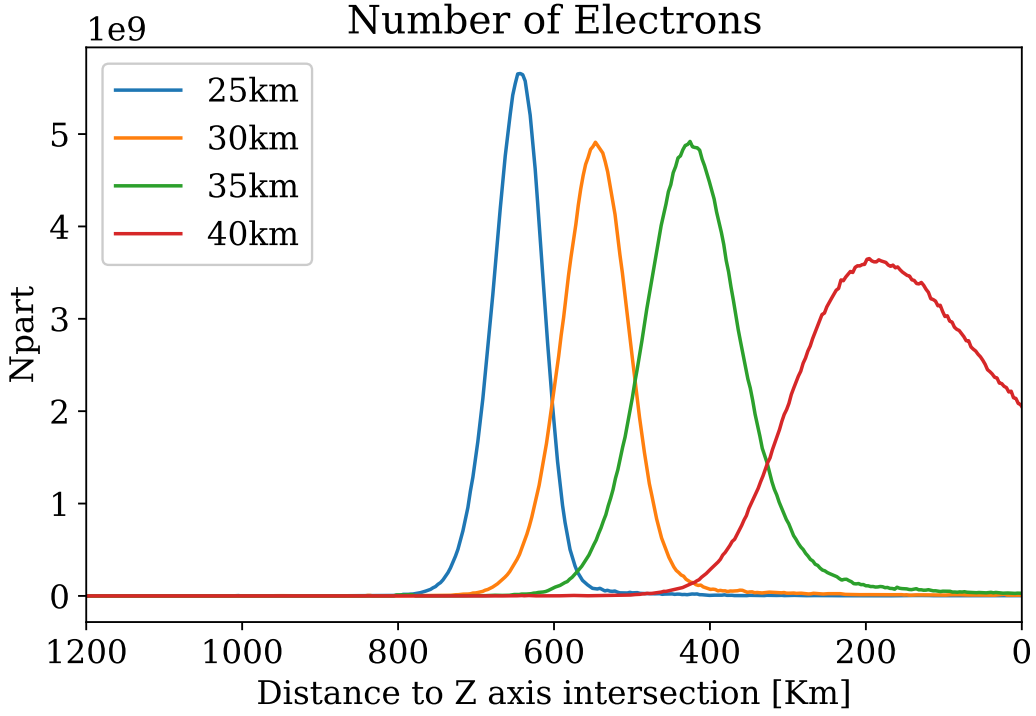
Use-case example: PUEO direct events

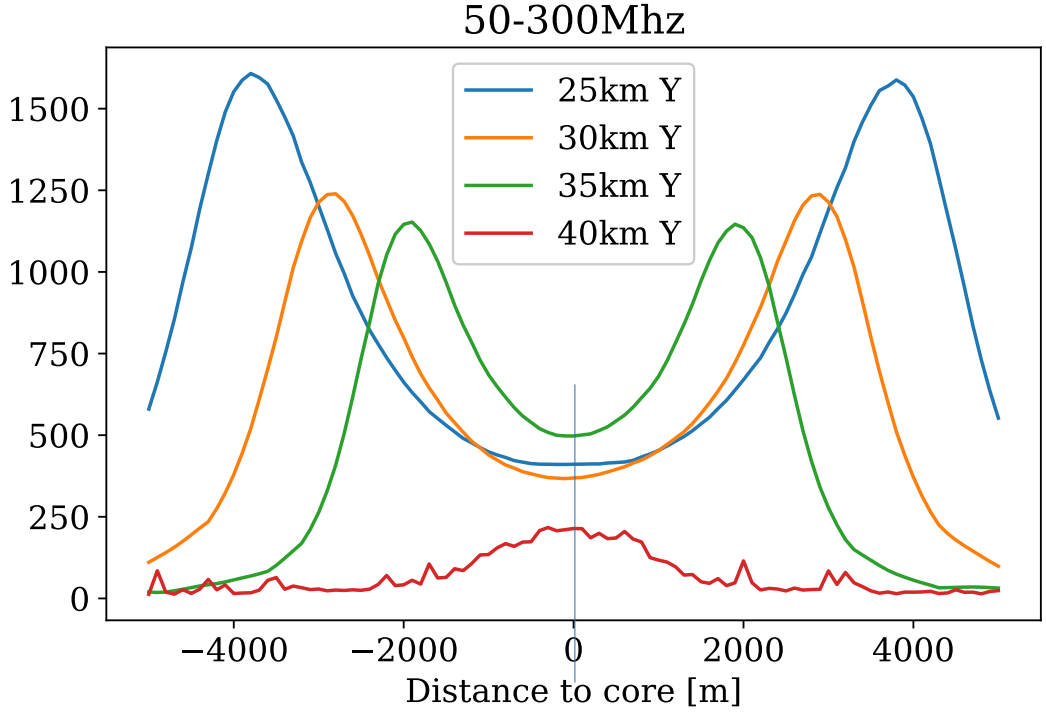
To scale!



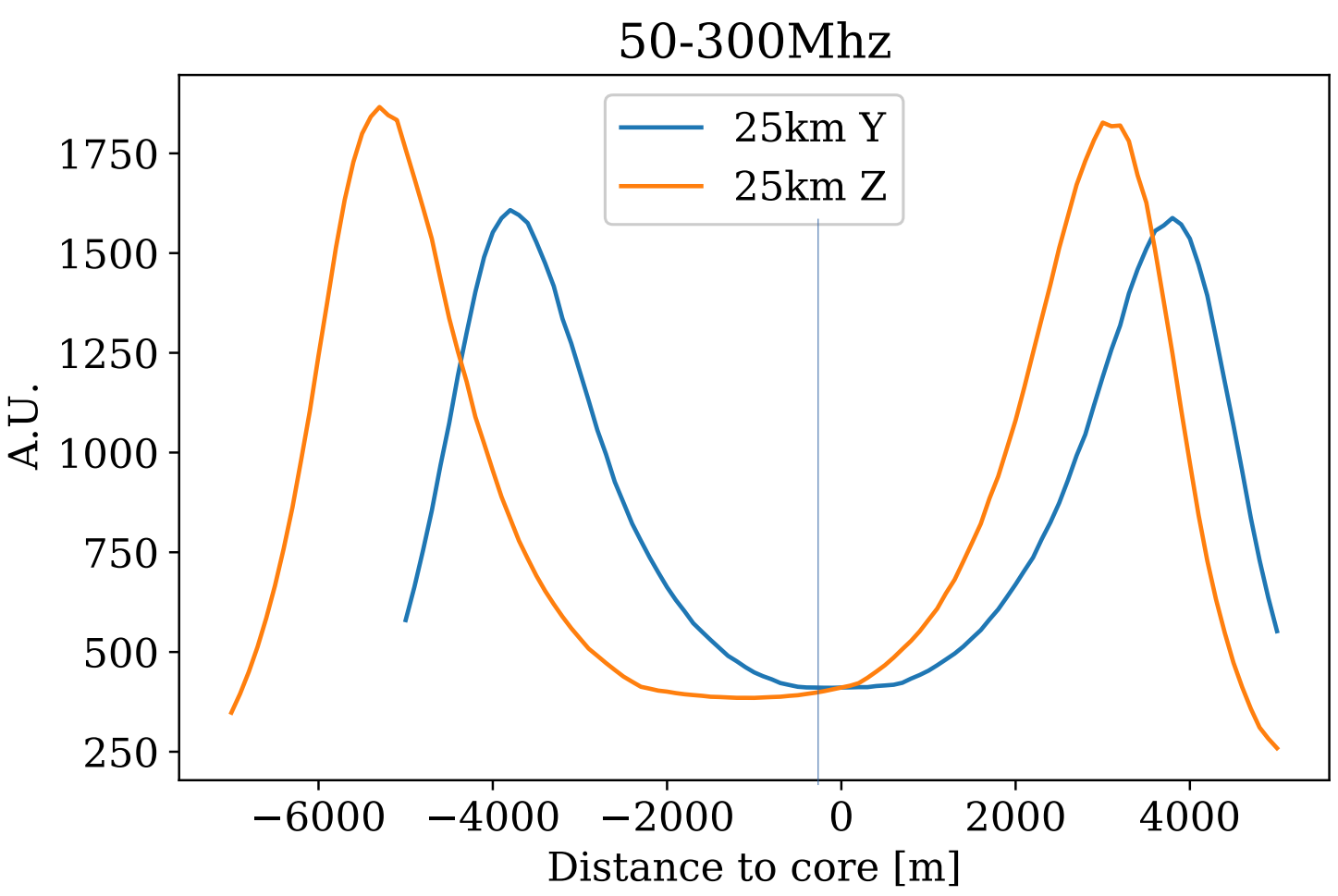
93.25 Zenith crossing the Z axis at 35 km altitude, Injected at 1500 Km from the crossing, Normaly t=0 at the crossing, but this is also configurable.

ZHAireS 1.0.30a + RASPASS

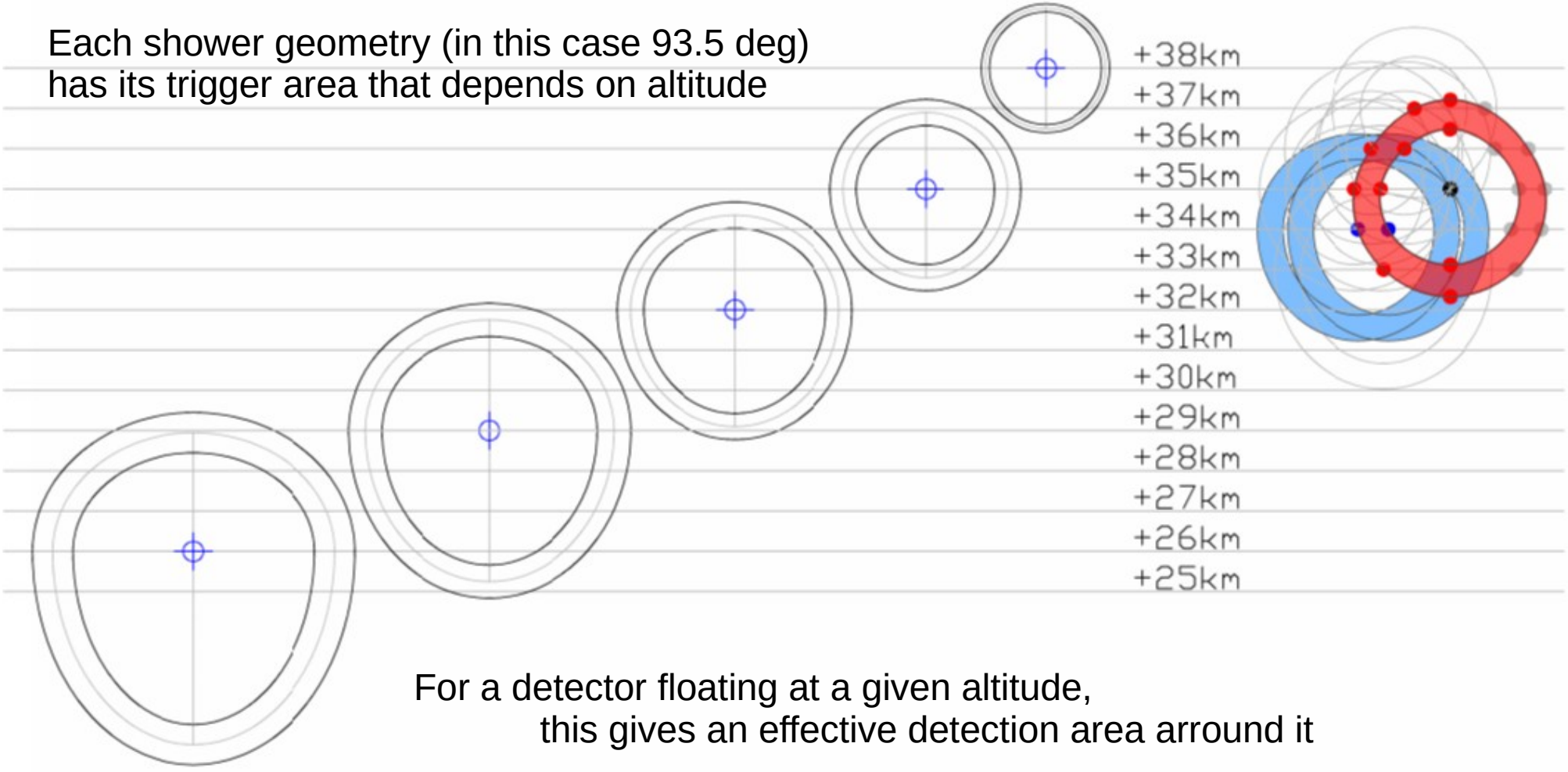




Reffractive Displacement: see 2005.06775

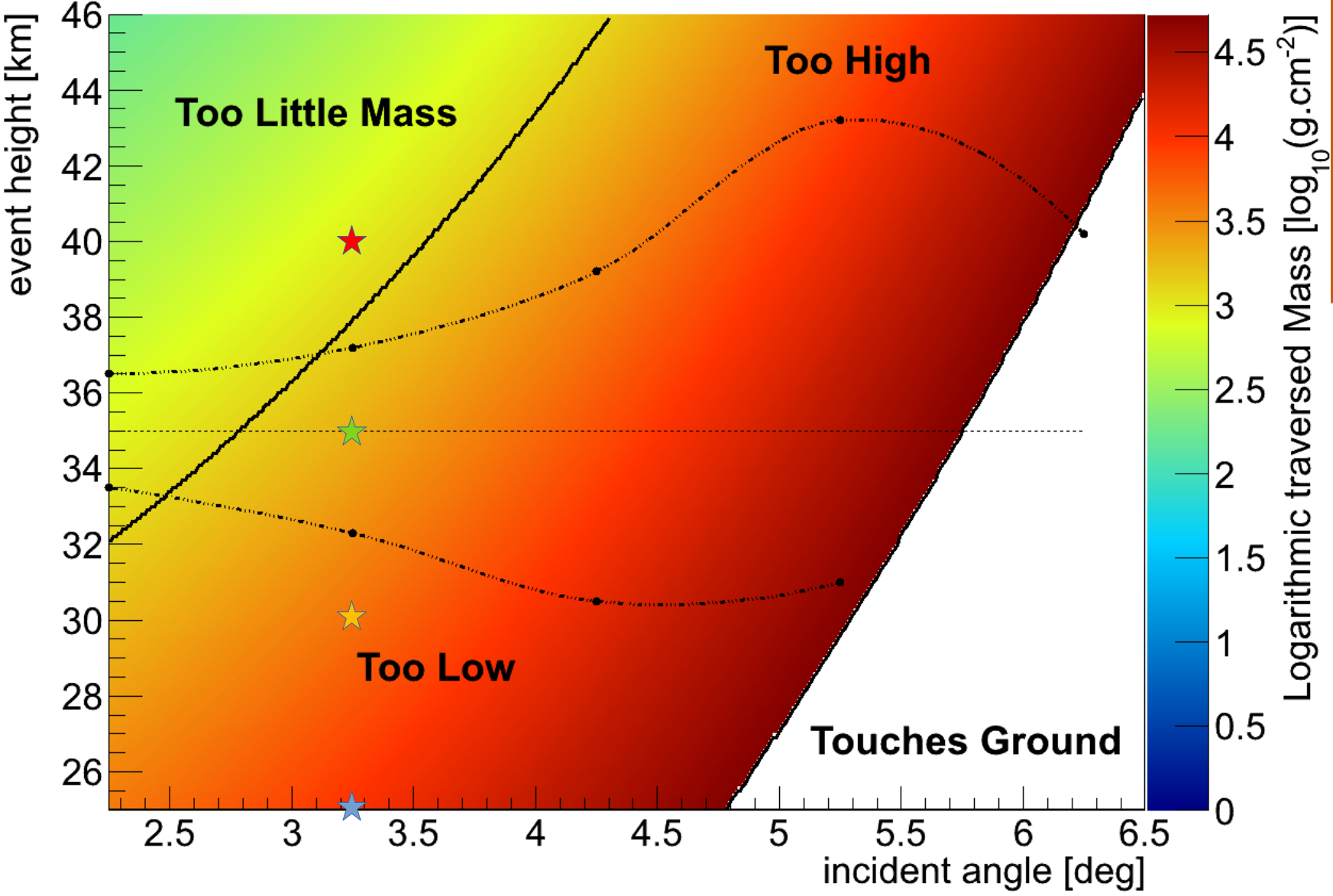


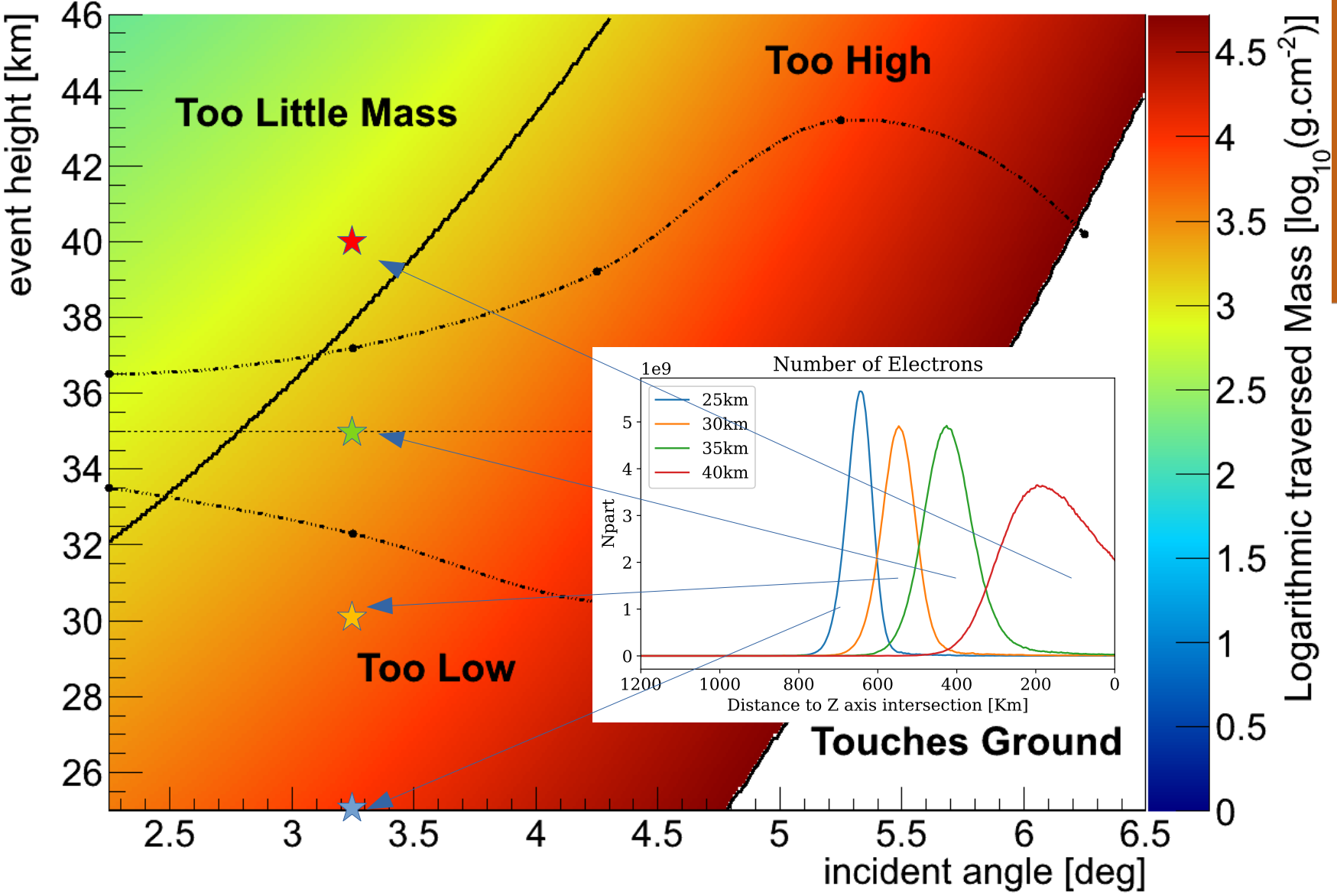
Each shower geometry (in this case 93.5 deg)
has its trigger area that depends on altitude



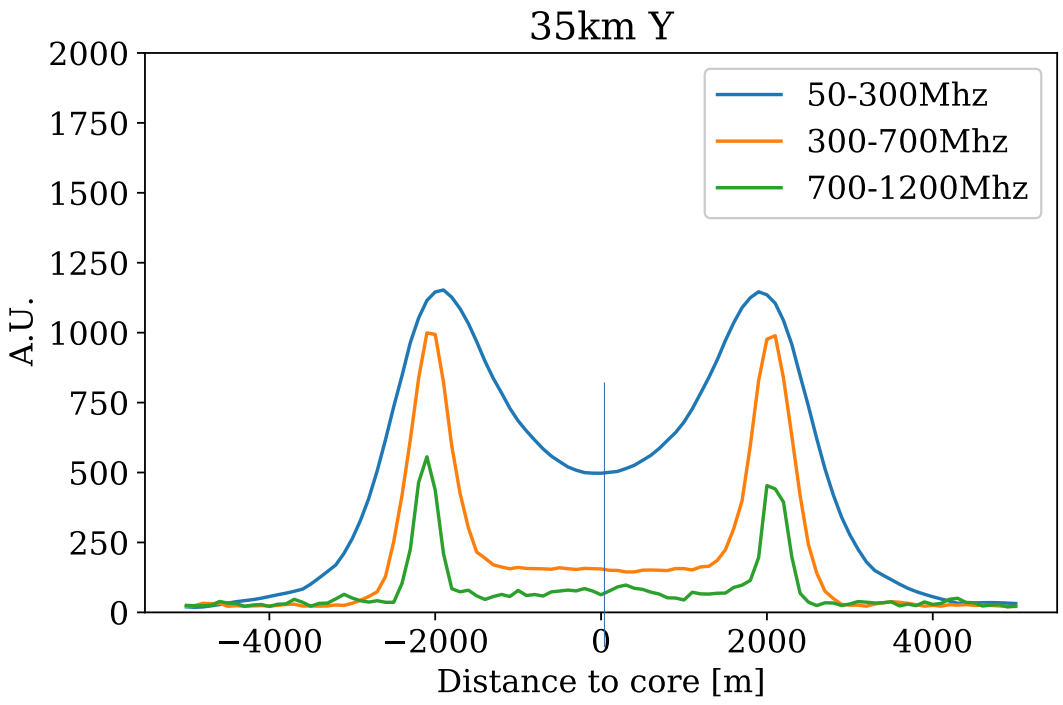
For a detector floating at a given altitude,
this gives an effective detection area arround it

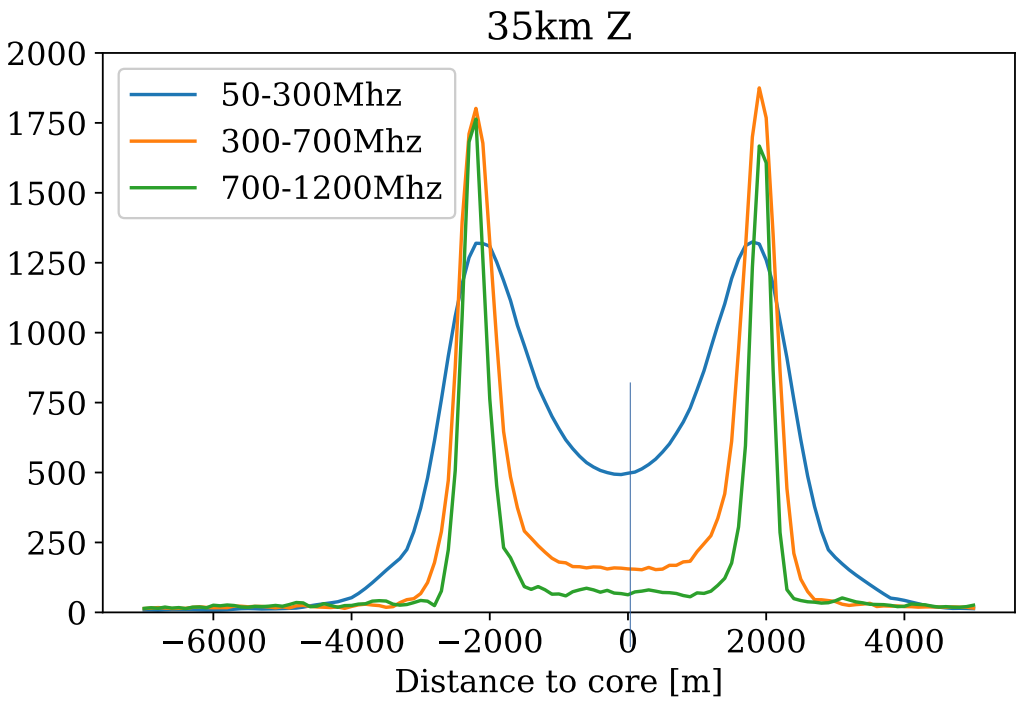
Now you need to cover all the geometry phase space ->


Too Little Mass
Too High
Too Low
Touches Ground
event height [km]
incident angle [deg]
Logarithmic traversed Mass [log10(g.cm-2)]
46
44
42
40
38
36
34
32
30
28
26
2.5
3
3.5
4
4.5
5
5.5
6
6.5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

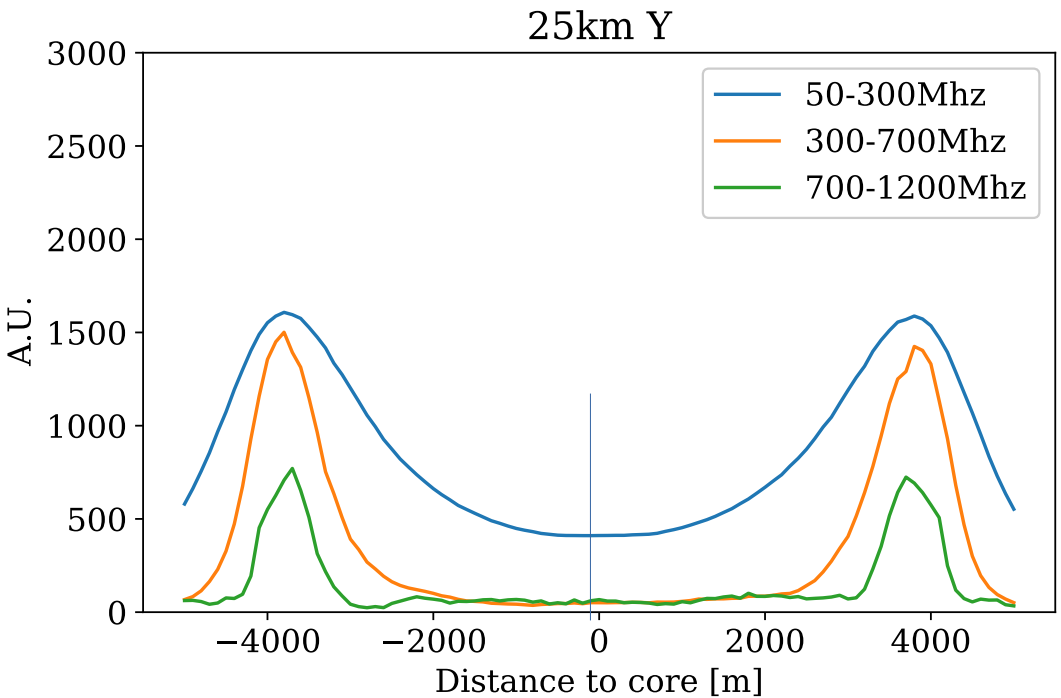

Too Little Mass
Too High
Too Low
Touches Ground
event height [km]
incident angle [deg]
Logarithmic traversed Mass [log10(g.cm-2)]
Number of Electrons
1e9
Npart
Distance to Z axis intersection [Km]
25km
30km
35km
40km

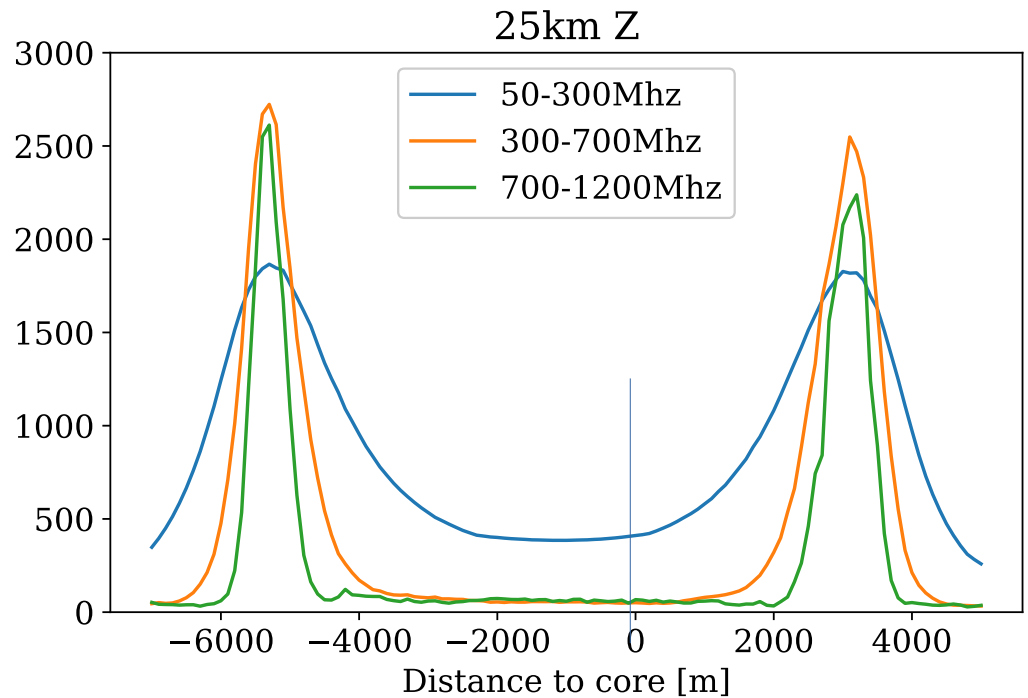
Top-side Asymmetry!



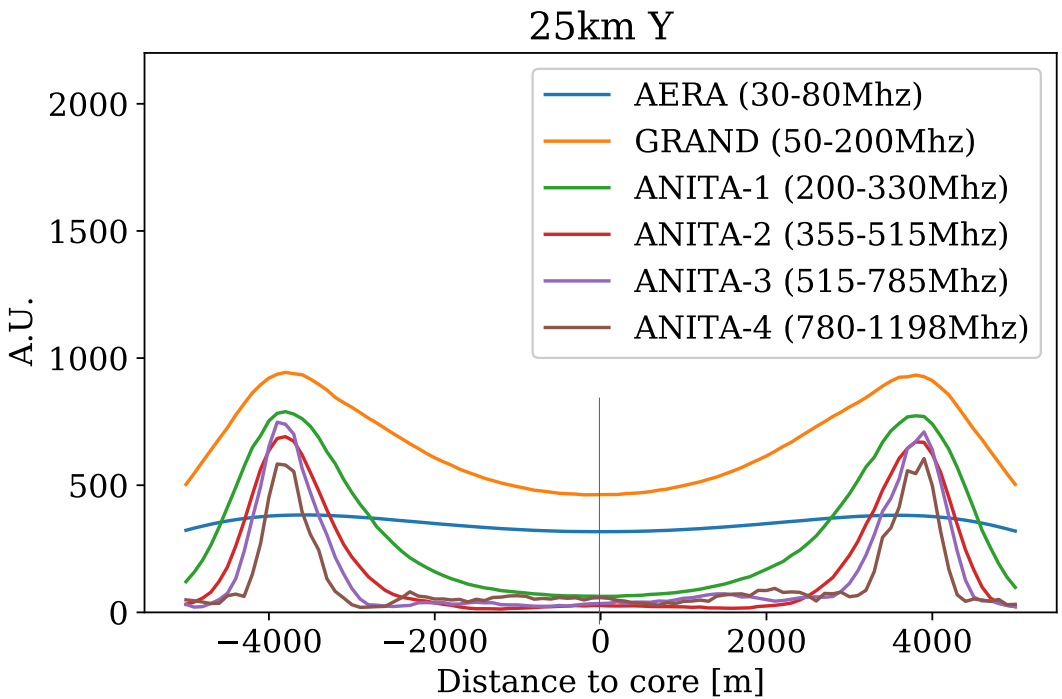


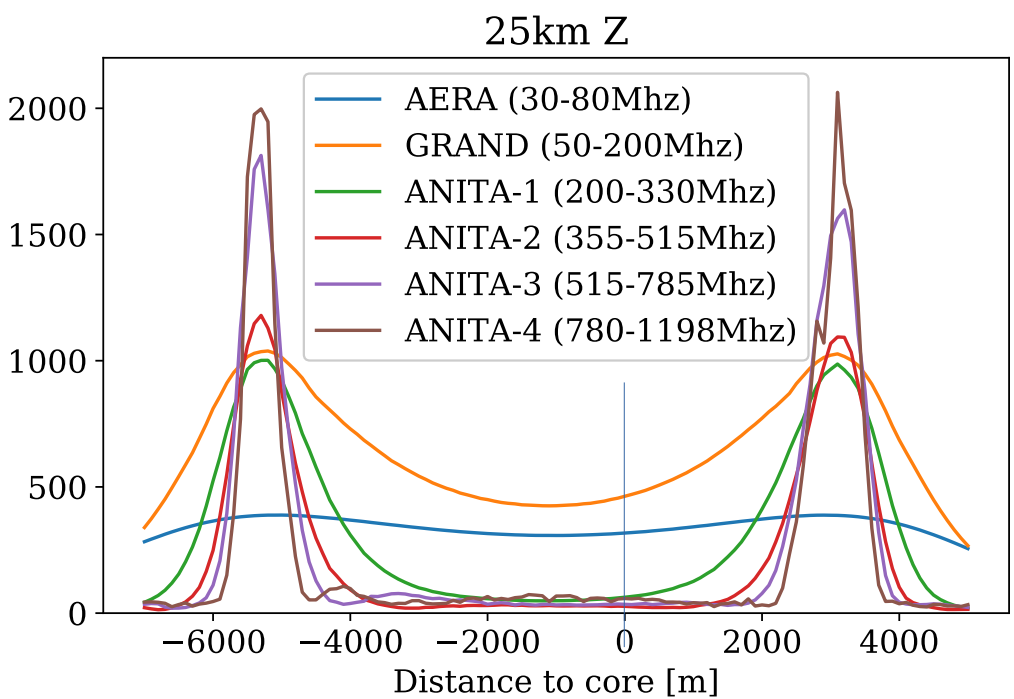
Top-side Asymmetry + refraction



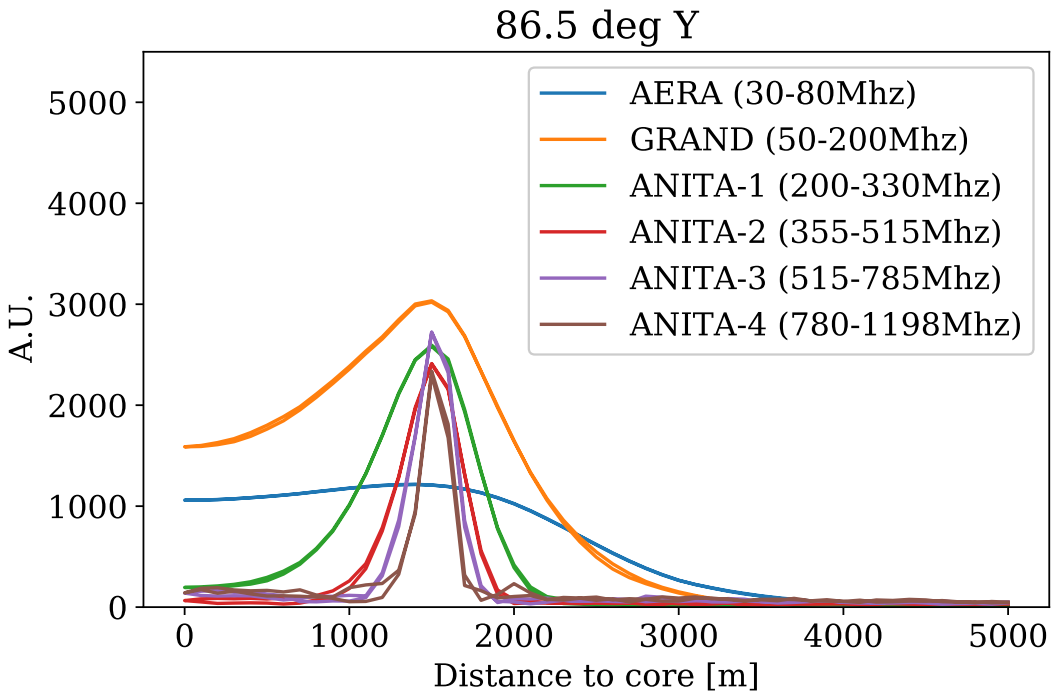


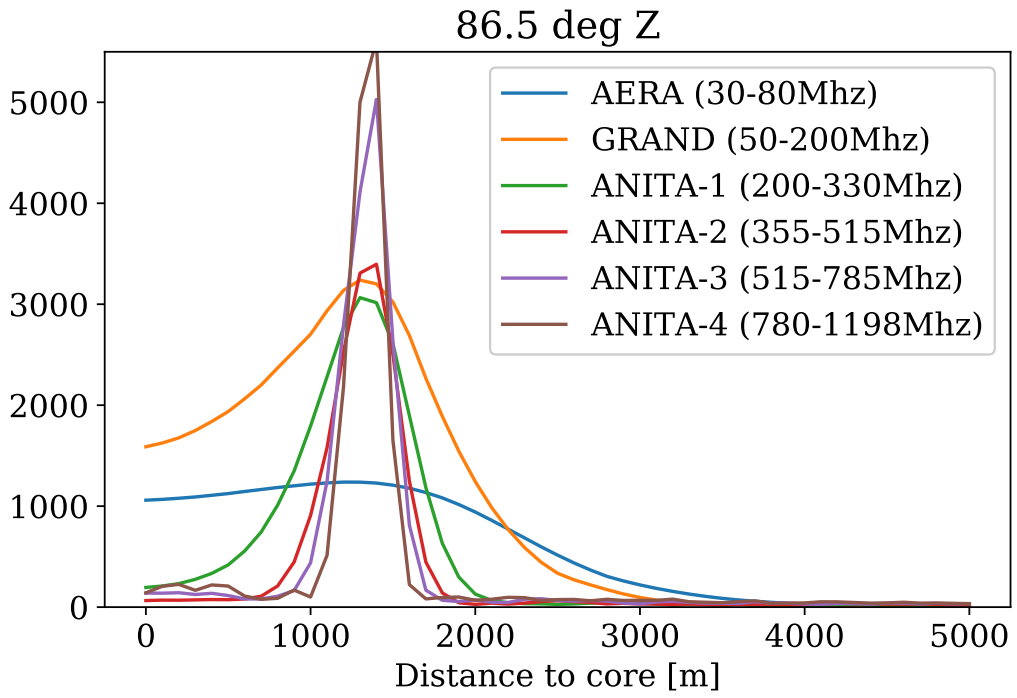
Top-side Asymmetry: multi-band





Top-side Asymmetry:also at ground

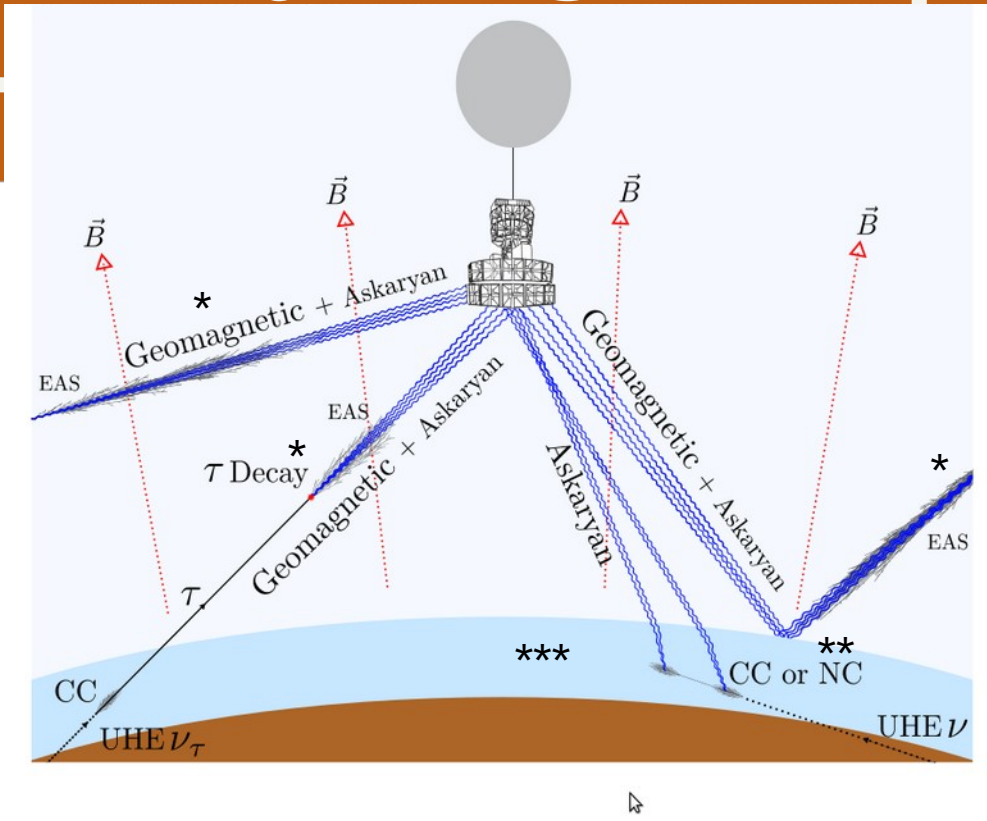




ZHAIRES can do everything(*,**,***)

Reflections**
Simulations of reflected radio signals from cosmic ray induced air showers (1502.02117)

In-ice sims with TIERRAS***
(the origin of ZHAireS! -> 1005.0552)
https://doi.org/10.1016/j.cpc.2009.09.022
ZHAireS could be used in dense media with some changes, ask me if you are interested.



* as-is
** with some good-will
*** with more good-will

New ZHAireS 1.0.30a released

http://aires.fisica.unlp.edu.ar/zhaires/

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- Only cosmetic changes from the radio part since previous version (1.0.28)

  → Adapted for changes in Aires 19.04.08 (previous version was for 19.04.00)

- **Aires 19.04.08 solves a bug introduced in Aires 19.04.00**

- Aires 19.04.00 had disabled the forced decay of short lived hadrons in post-LHC hadronic models. Short lived hadrons were propagated, but some where not given the posibility to have a new hadronic interaction. Most of these short lived hadrons decay inmediatelly anyway (with lifetimes of 10^{-12} ns), but for example Σ particles have lifetimes of 0.8 ns. When by chance a very energetic Σ was generated, its decay mean free path could become very large and the particle could reach ground, taking energy out of the cascade and giving a smaller cascade.

- This bug resulted in some showers having significantly lower electromagnetic component, and thus smaller radio emission. (Bug discovered by H. Brans and J. Alvarez-Muniz...thanks!).